

FIG 1

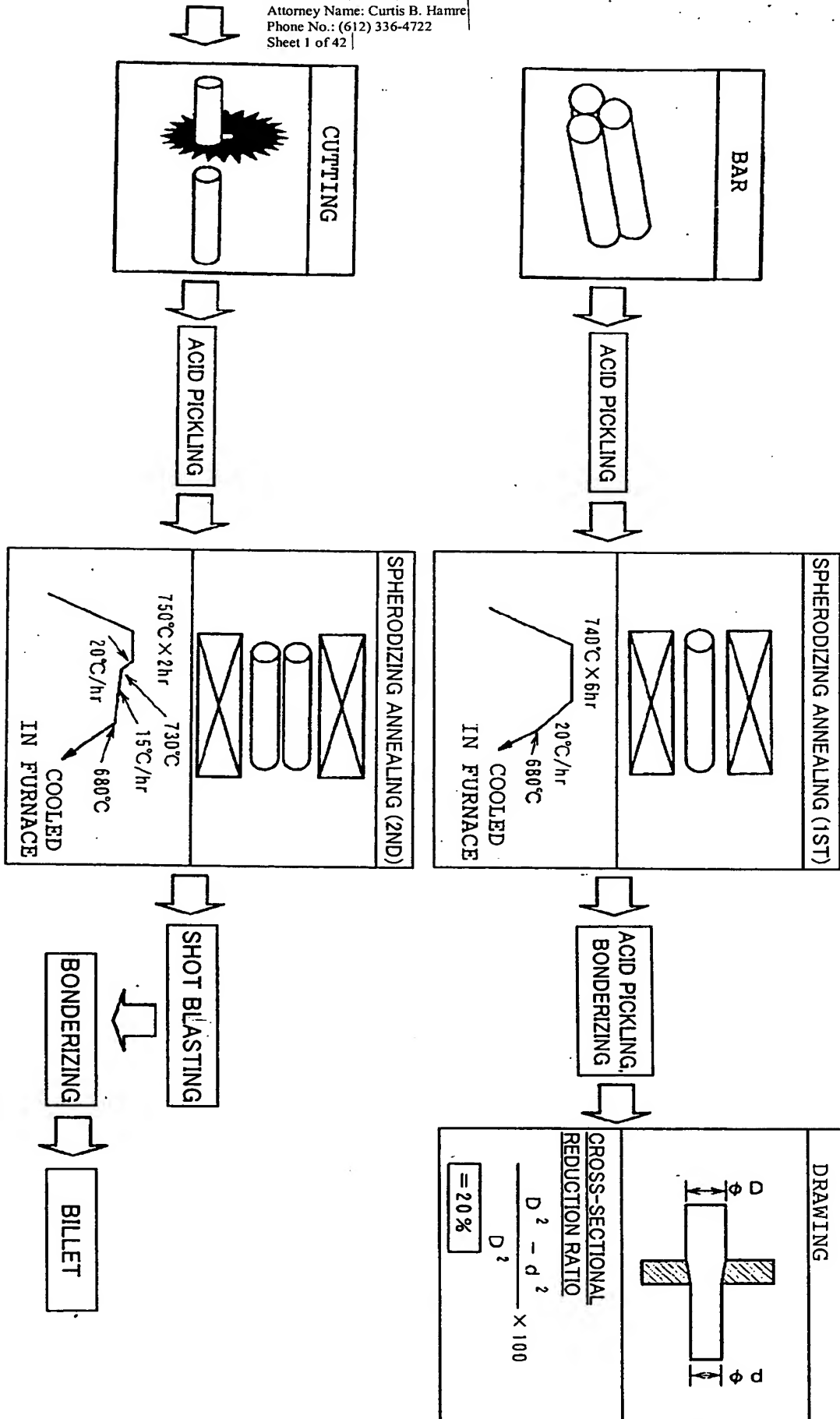


FIG. 2

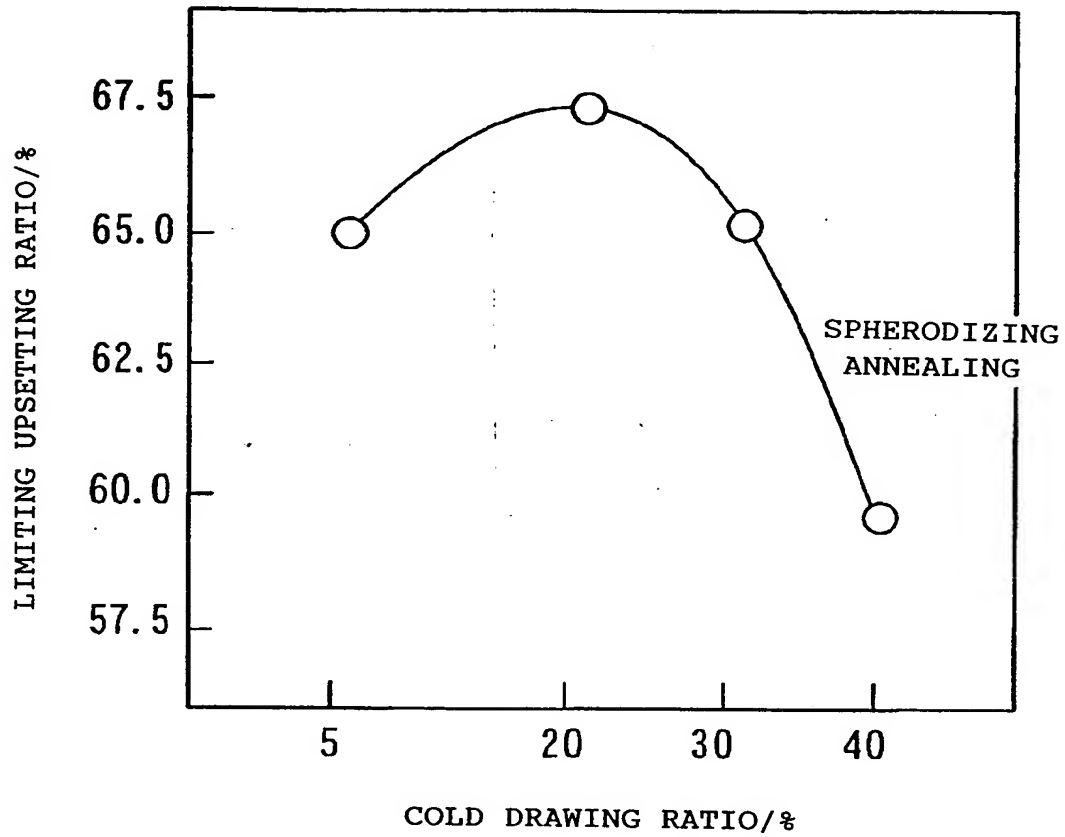
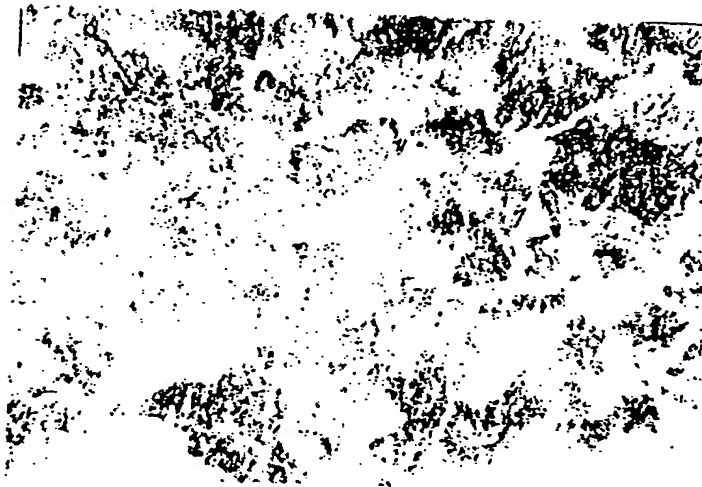


FIG. 3



(a)



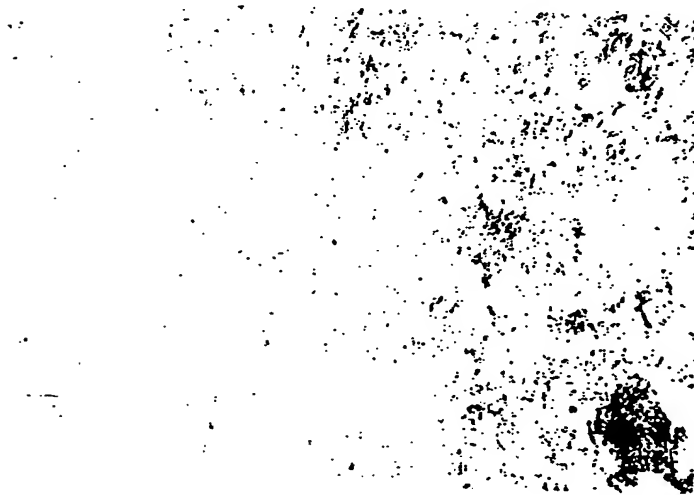
(b)

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FIG. 4



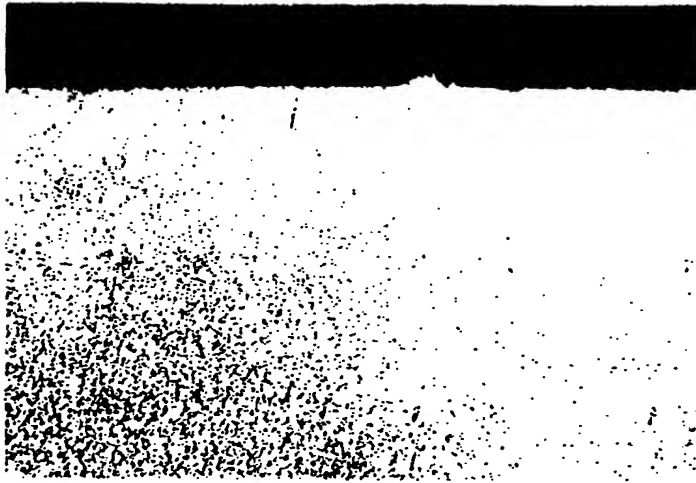
(a)



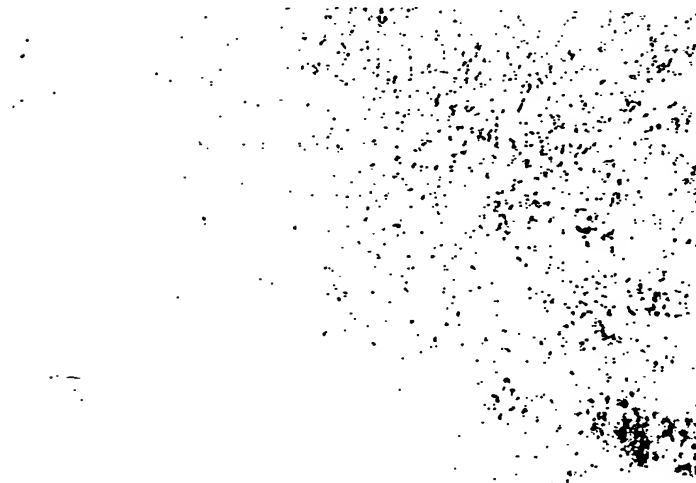
(b)

BEST AVAILABLE COPY

FIG. 5



(a)



(b)

BEST AVAILABLE COPY

FIG. 6

(A) MATERIAL 1

ASPECT RATIO = 506 %



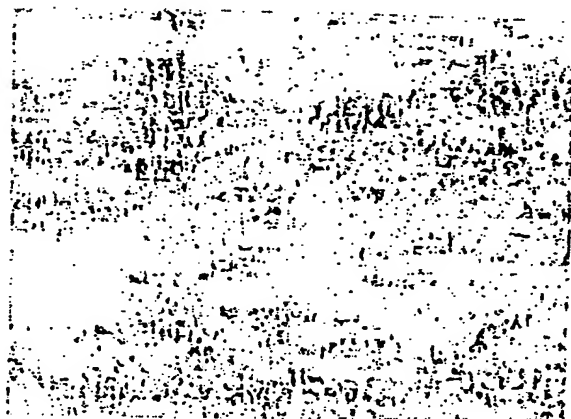
(B) MATERIAL 2

ASPECT RATIO = 347 %



(C) MATERIAL 3

ASPECT RATIO = 300 %



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FIG. 7

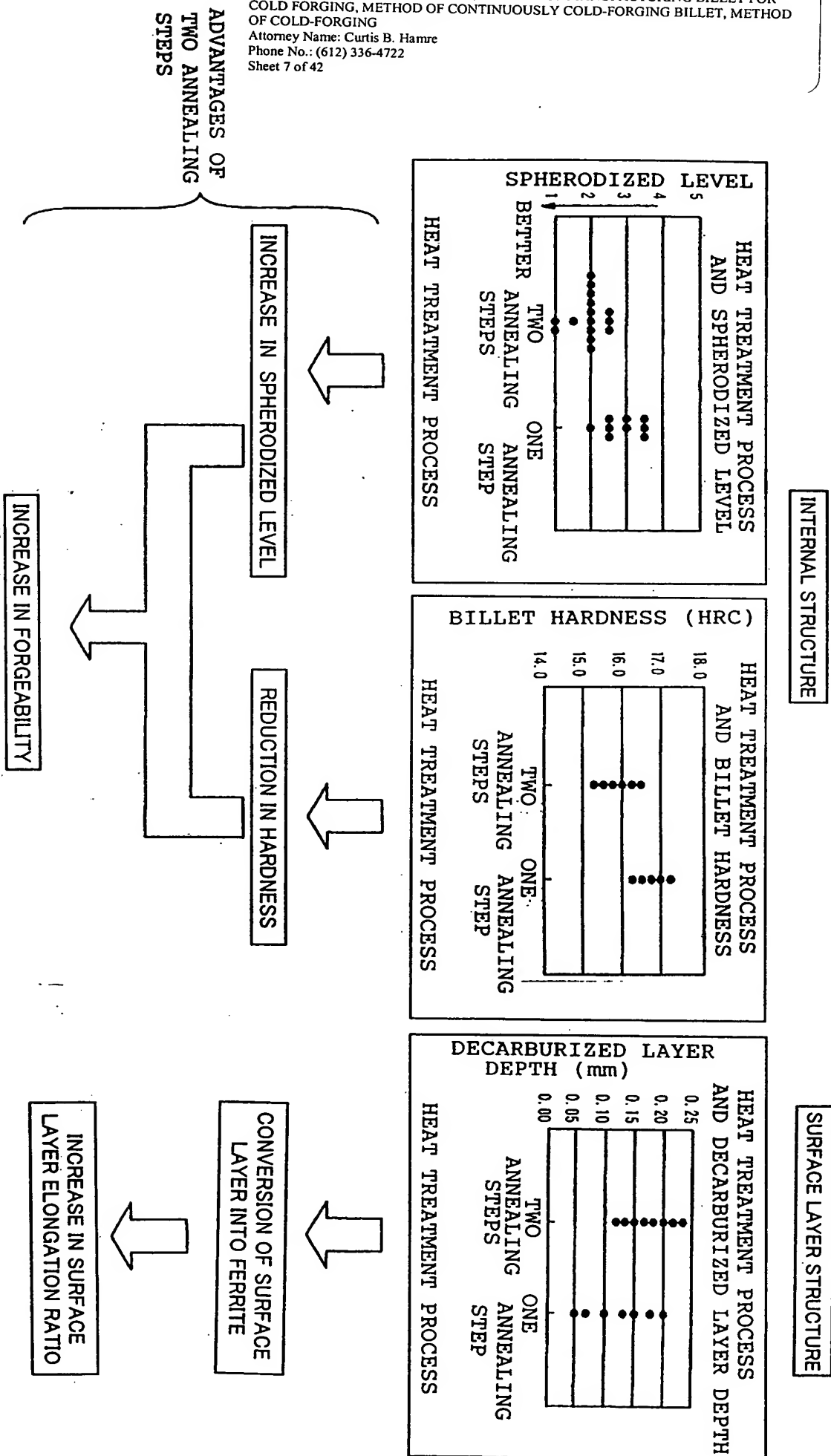


FIG. 8

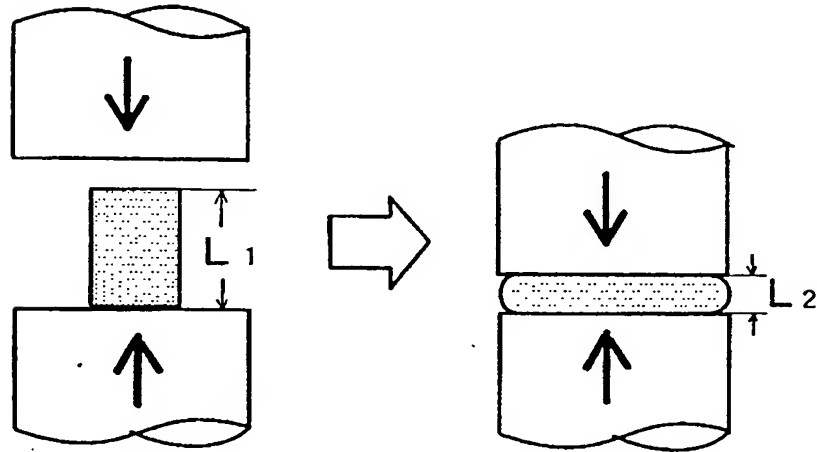




FIG. 9

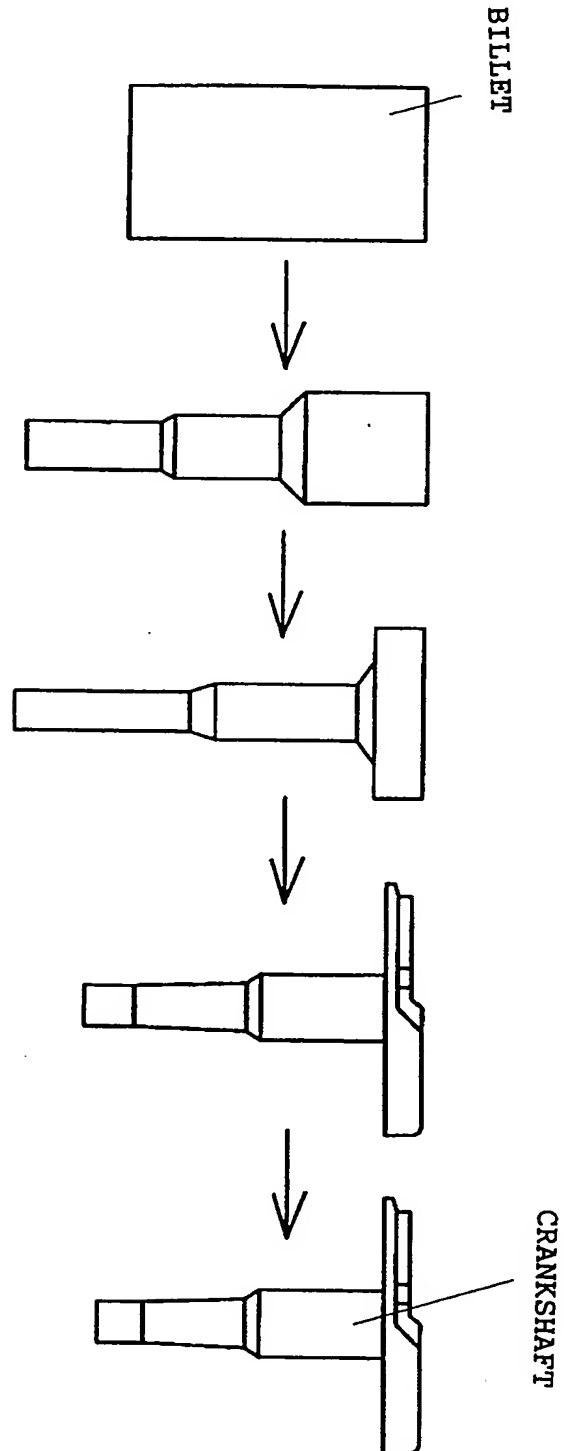


FIG. 10

Inventor: Ando, et al  
Docket No.: 12052.33USD1  
Title: BILLET FOR COLD FORGING, METHOD OF MANUFACTURING BILLET FOR COLD FORGING, METHOD OF CONTINUOUSLY COLD-FORGING BILLET. METHOD OF COLD-FORGING  
Attorney Name: Curtis B. Hamre  
Phone No.: (612) 336-4722  
Sheet 10 of 42

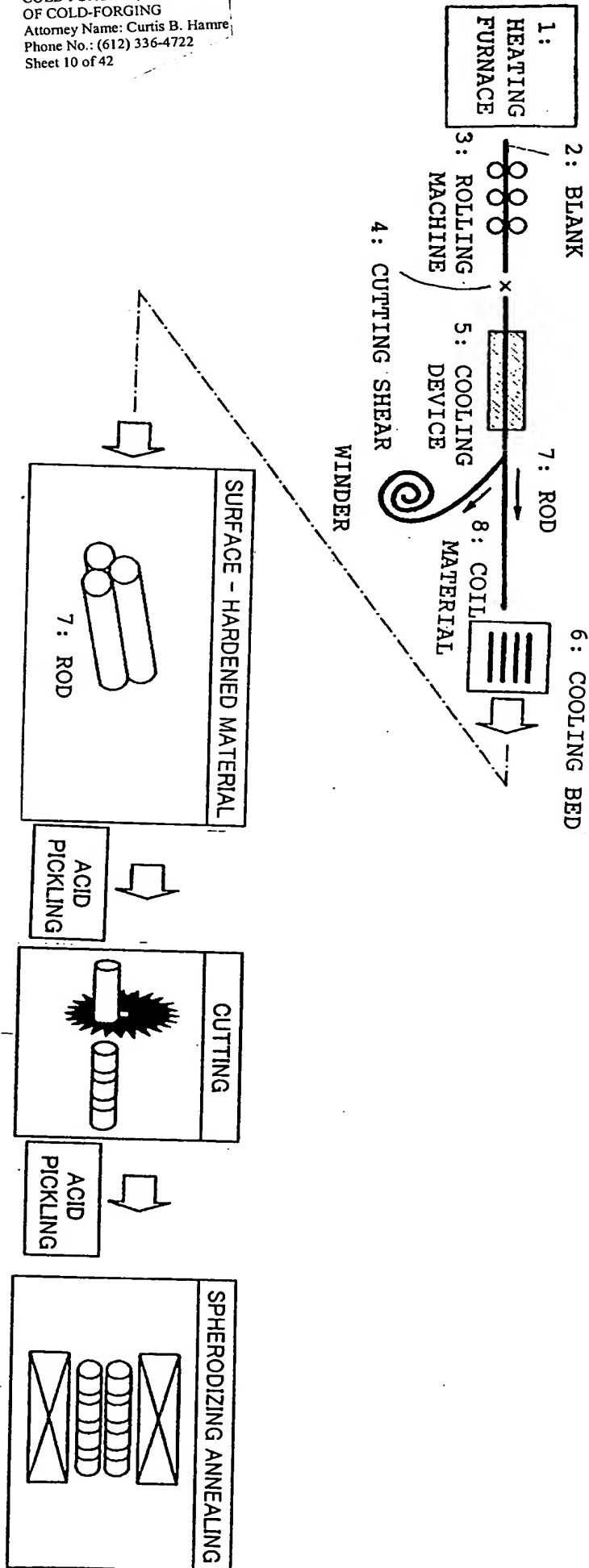


FIG. 11

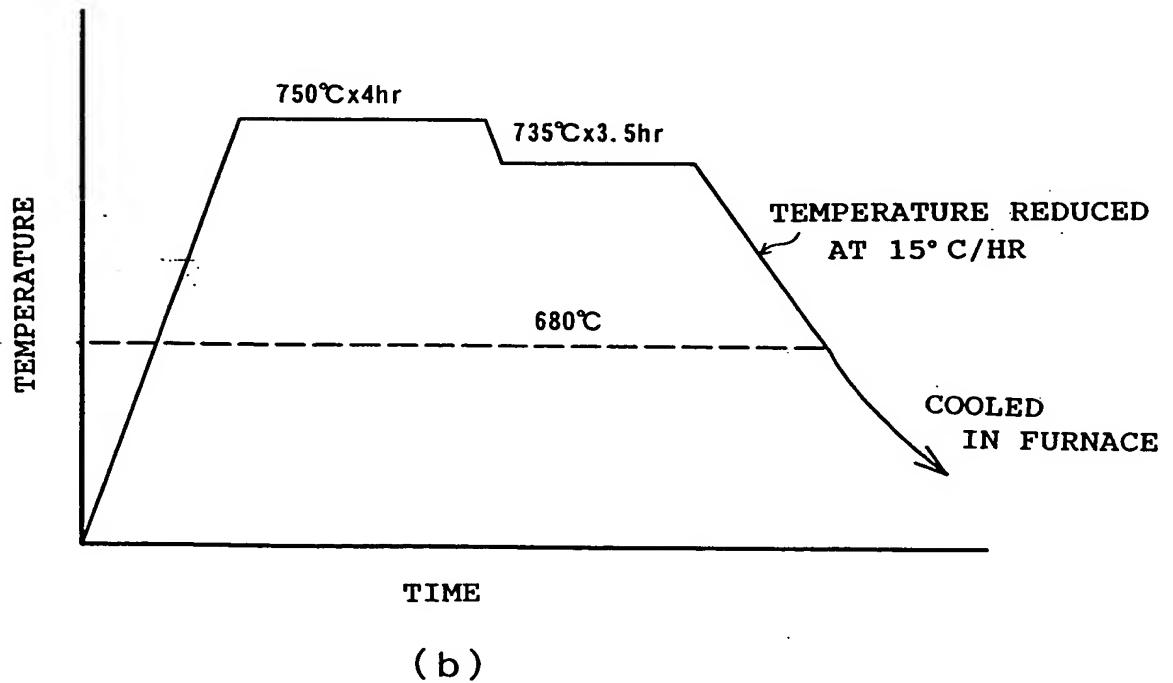
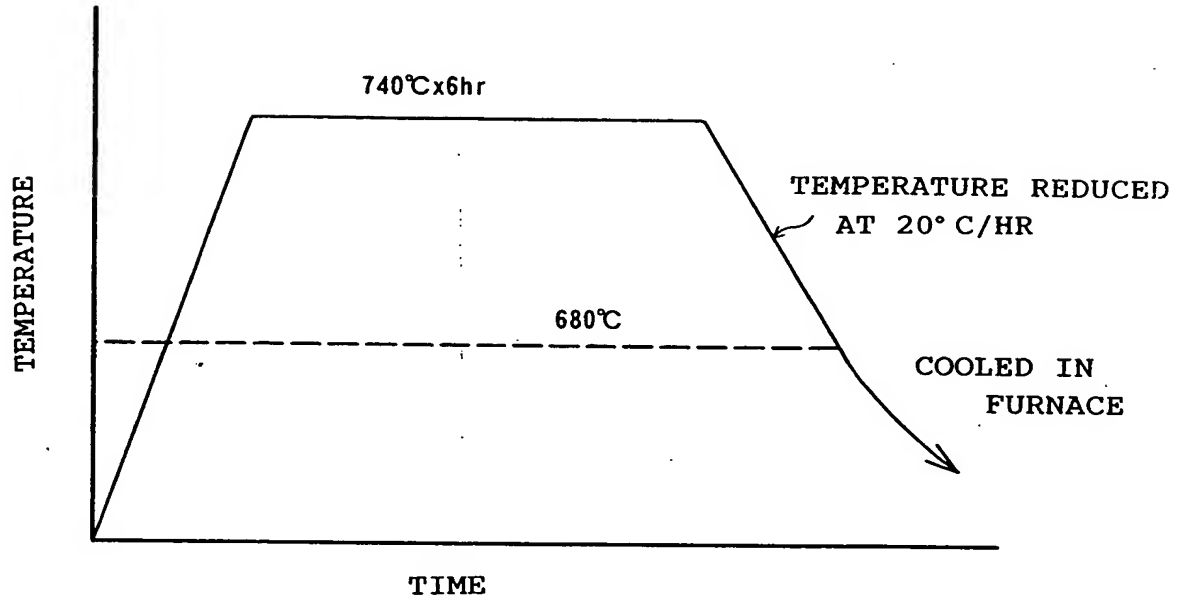
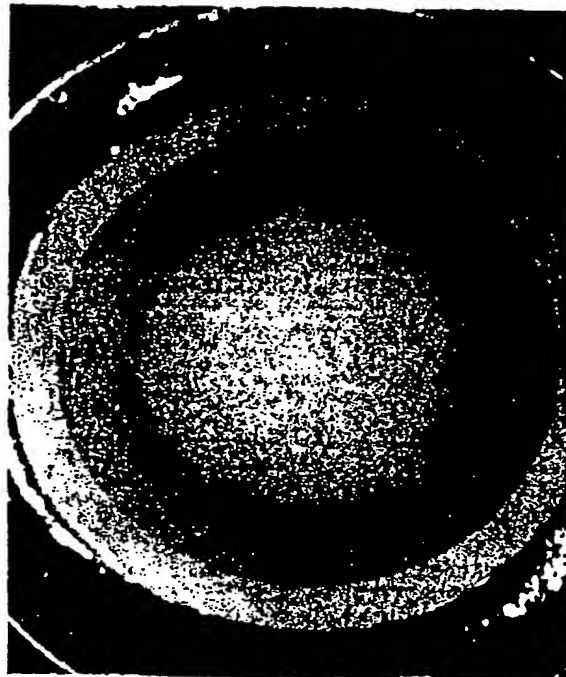
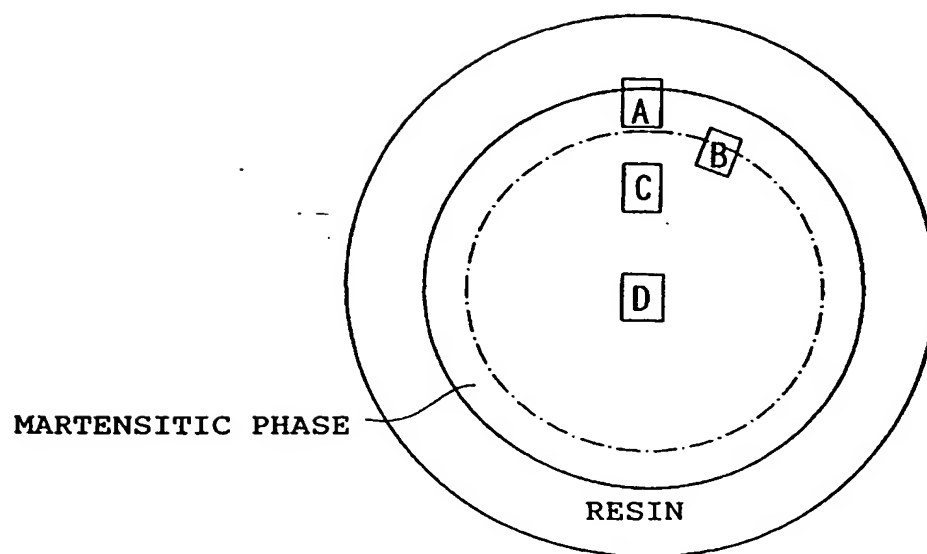


FIG. 12



MARTENSITIC MATERIAL  
(a) PRIOR TO SPHERODIZING ANNEALING  
× 2.1



(b)

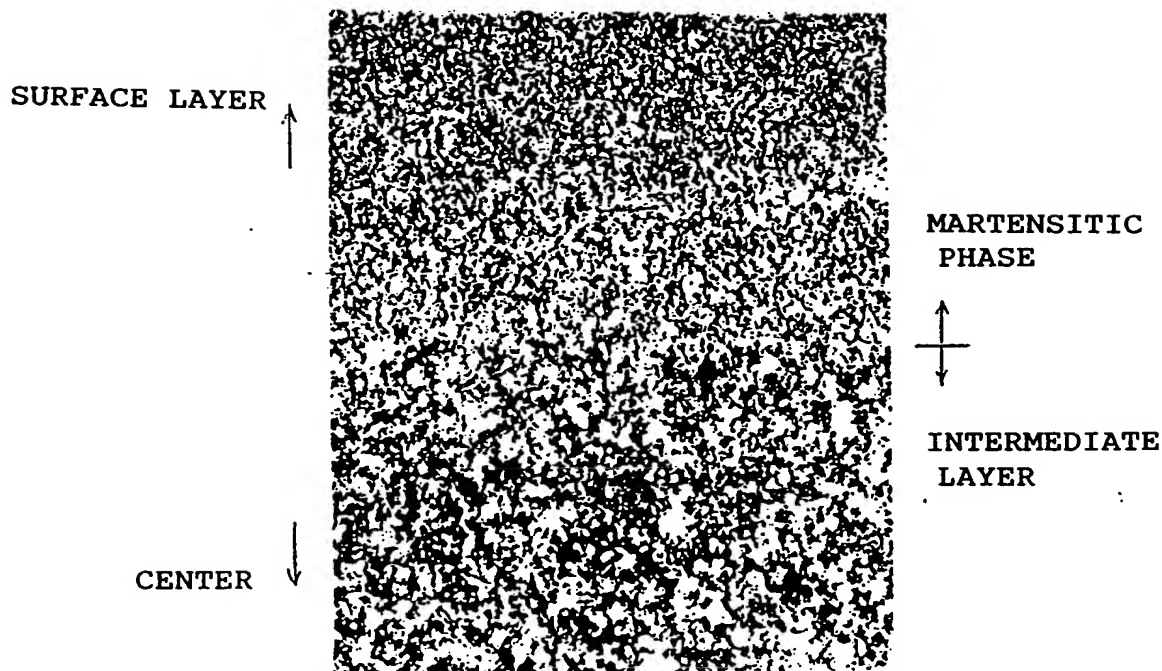
BEST AVAILABLE COPY

FIG. 13



PRIOR TO SPHERODIZING ANNEALING  
SURFACE LAYER  $\times 100$

FIG. 14



PRIOR TO SPHERODIZING ANNEALING  
SURFACE LAYER AND INTERMEDIATE LAYER  $\times 200$

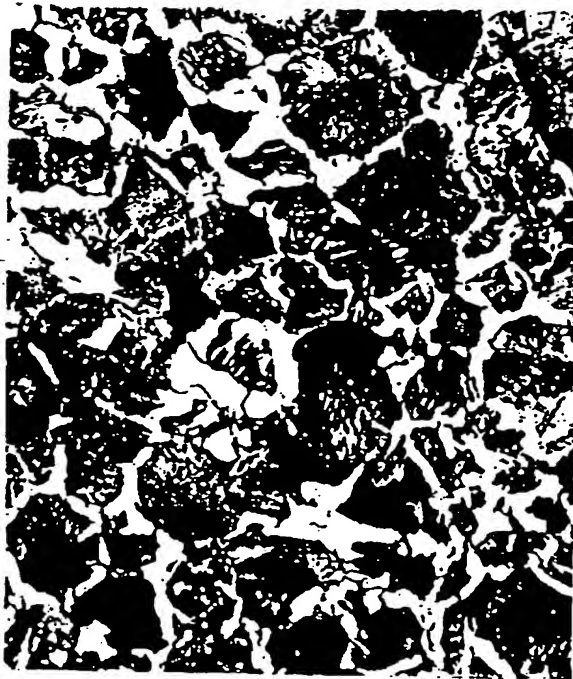
BEST AVAILABLE COPY

FIG. 15



PRIOR TO SPHERODIZING ANNEALING  
1/2 R PART  $\times 400$

FIG. 16



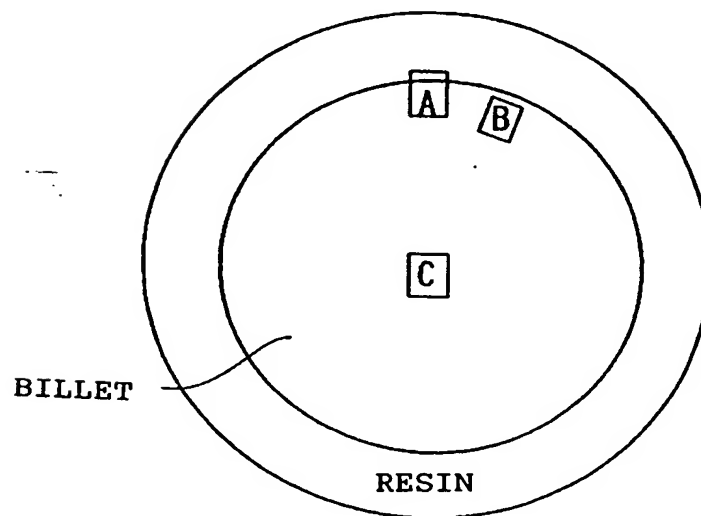
PRIOR TO SPHERODIZING ANNEALING  
CENTRAL PART  $\times 400$

FIG. 17



MARTENSITIC MATERIAL  
AFTER SPHERODIZING ANNEALING PATTERN 1  
x 2. 1

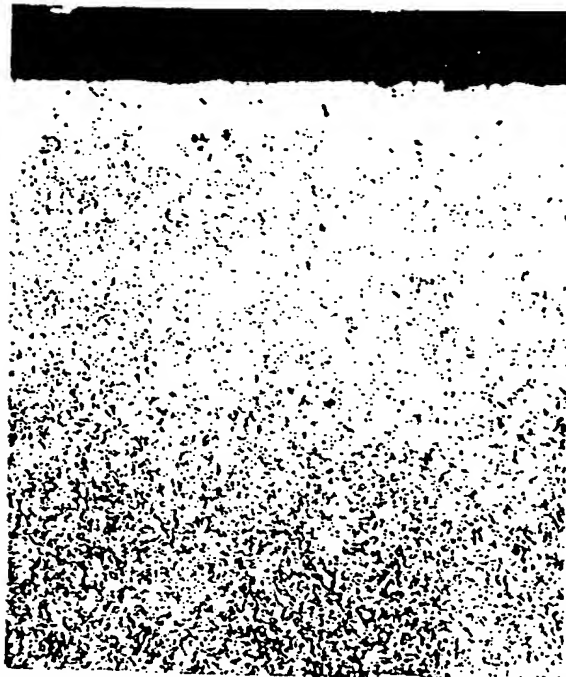
(a)



(b)

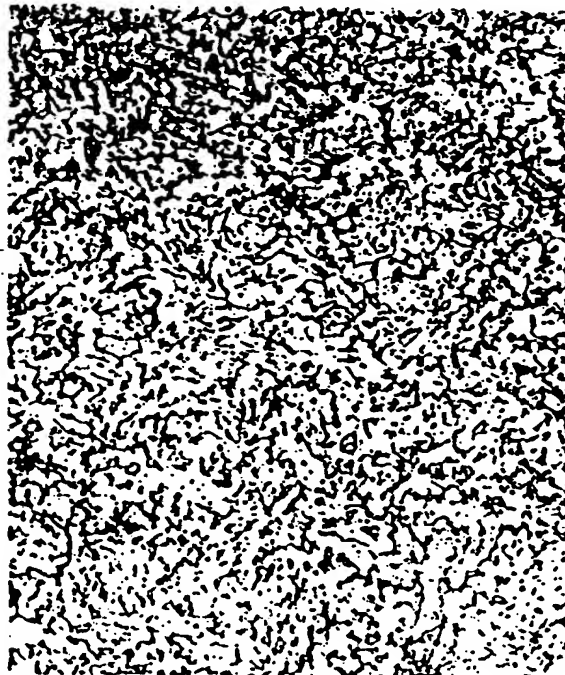
BEST AVAILABLE COPY

FIG. 18



AFTER SPHERODIZING ANNEALING PATTERN 1  
SURFACE LAYER  $\times 100$

FIG. 19



AFTER SPHERODIZING ANNEALING PATTERN 1  
SURFACE LAYER  $\times 400$

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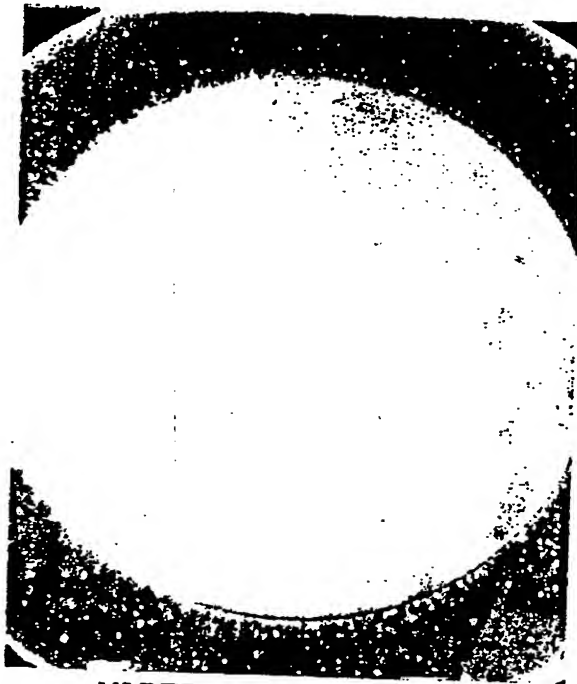
FIG. 20



AFTER SPHERODIZING ANNEALING PATTERN 1  
1/2 R PART  $\times$  400

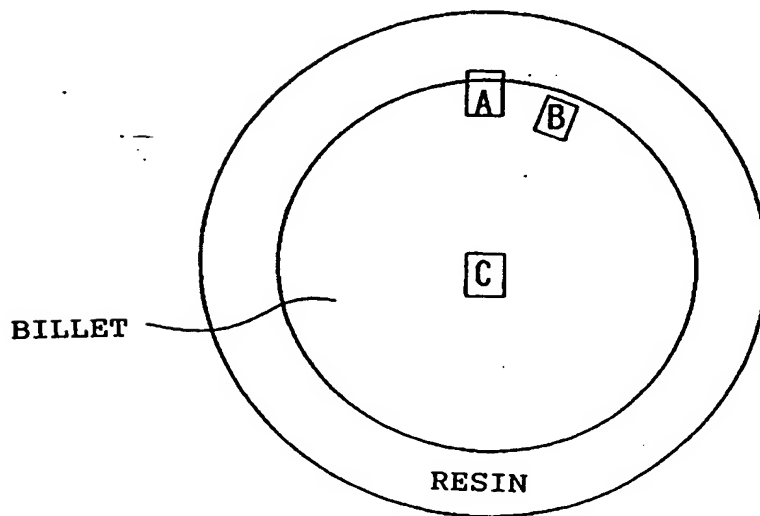
BEST AVAILABLE COPY

FIG. 21



MARTENSITIC MATERIAL  
AFTER SPHERODIZING ANNEALING PATTERN 2  
x 2. 1

(a)



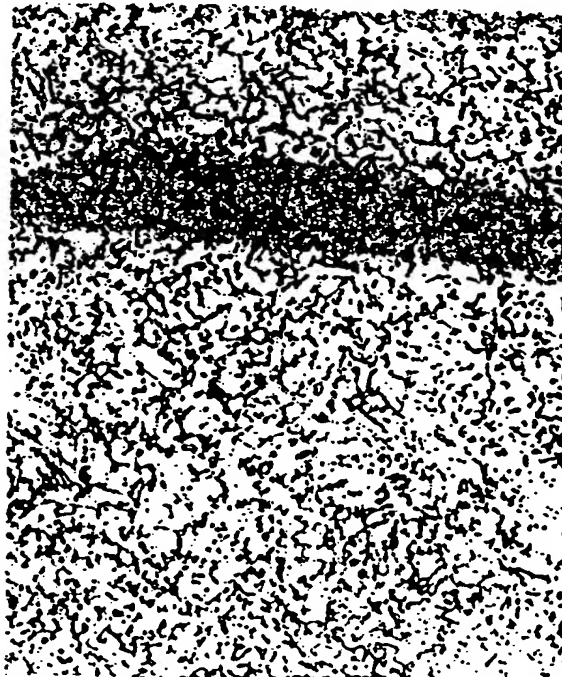
(b)

FIG. 22



AFTER SPHERODIZING ANNEALING PATTERN 2  
SURFACE LAYER  $\times 100$

FIG. 23



AFTER SPHERODIZING ANNEALING PATTERN 2  
SURFACE LAYER  $\times 400$

BEST AVAILABLE COPY

FIG. 24



AFTER SPHERODIZING ANNEALING PATTERN 2  
1/2 R PART  $\times$  400

BEST AVAILABLE COPY

FIG. 25

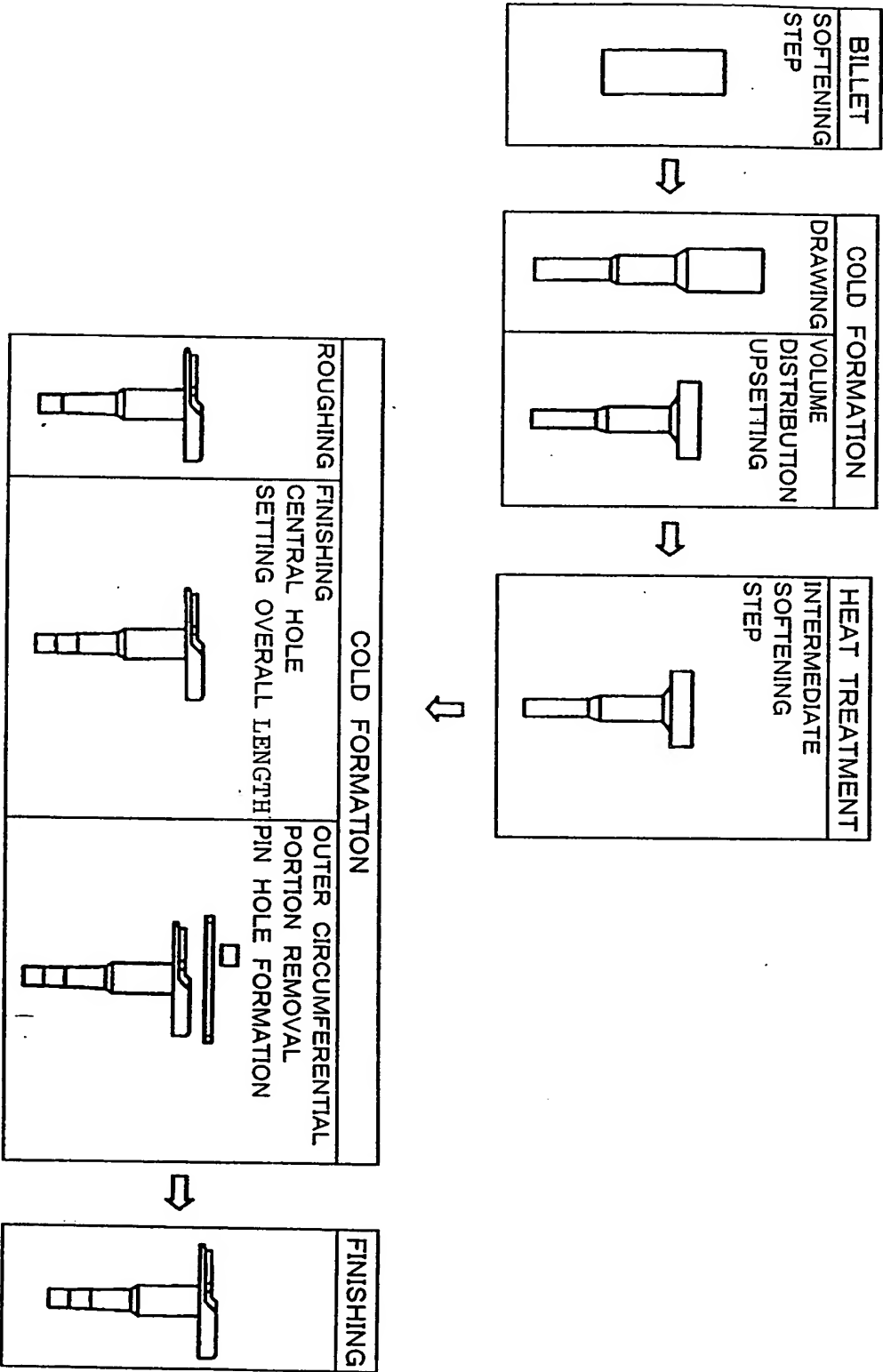


FIG. 26

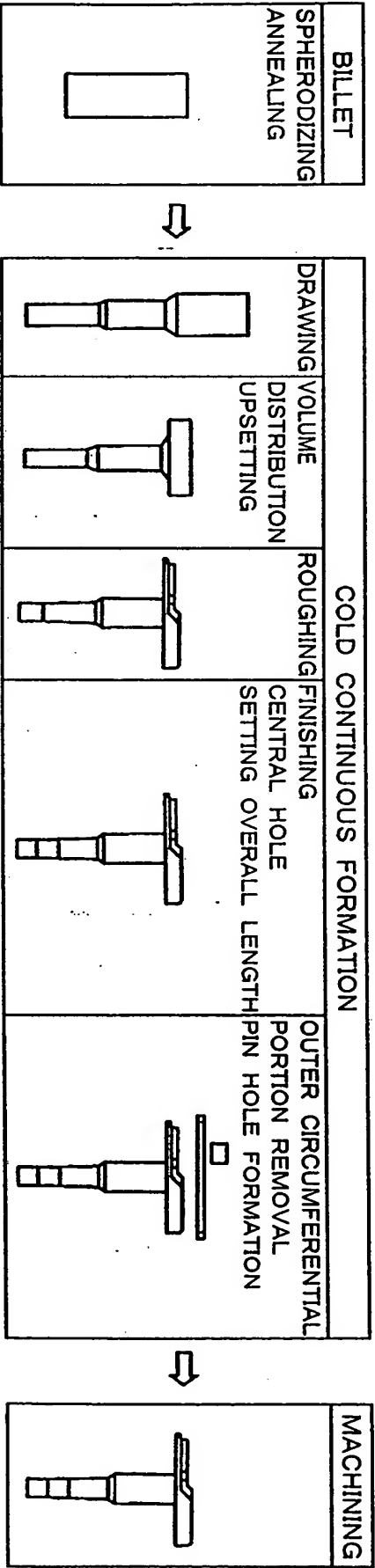


FIG. 27

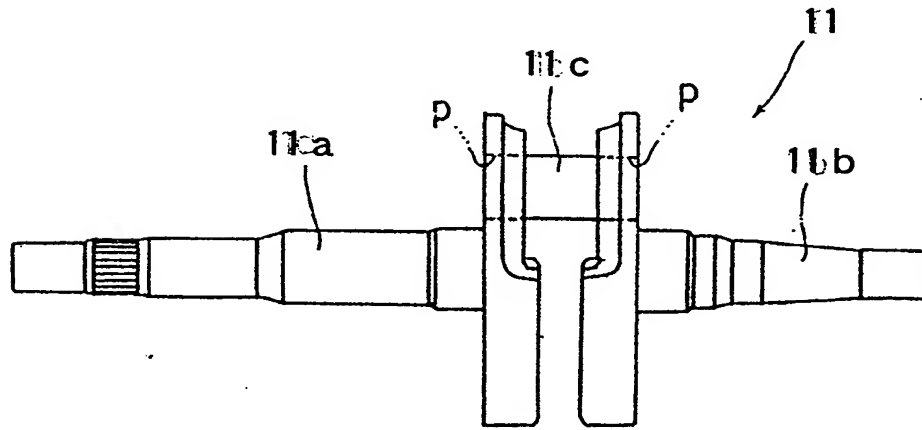


FIG. 28

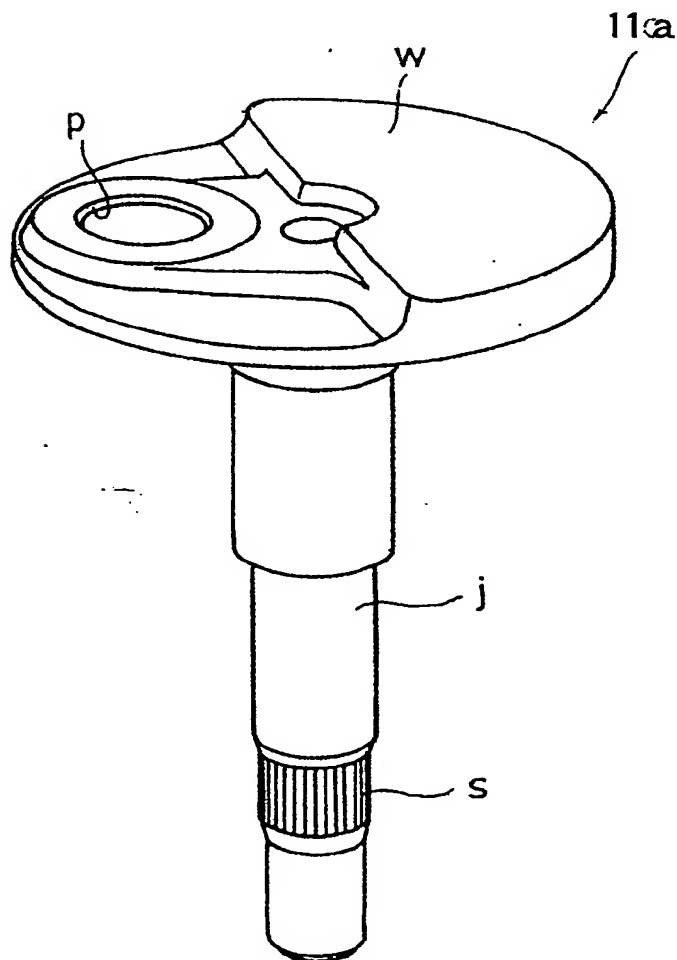


FIG. 29

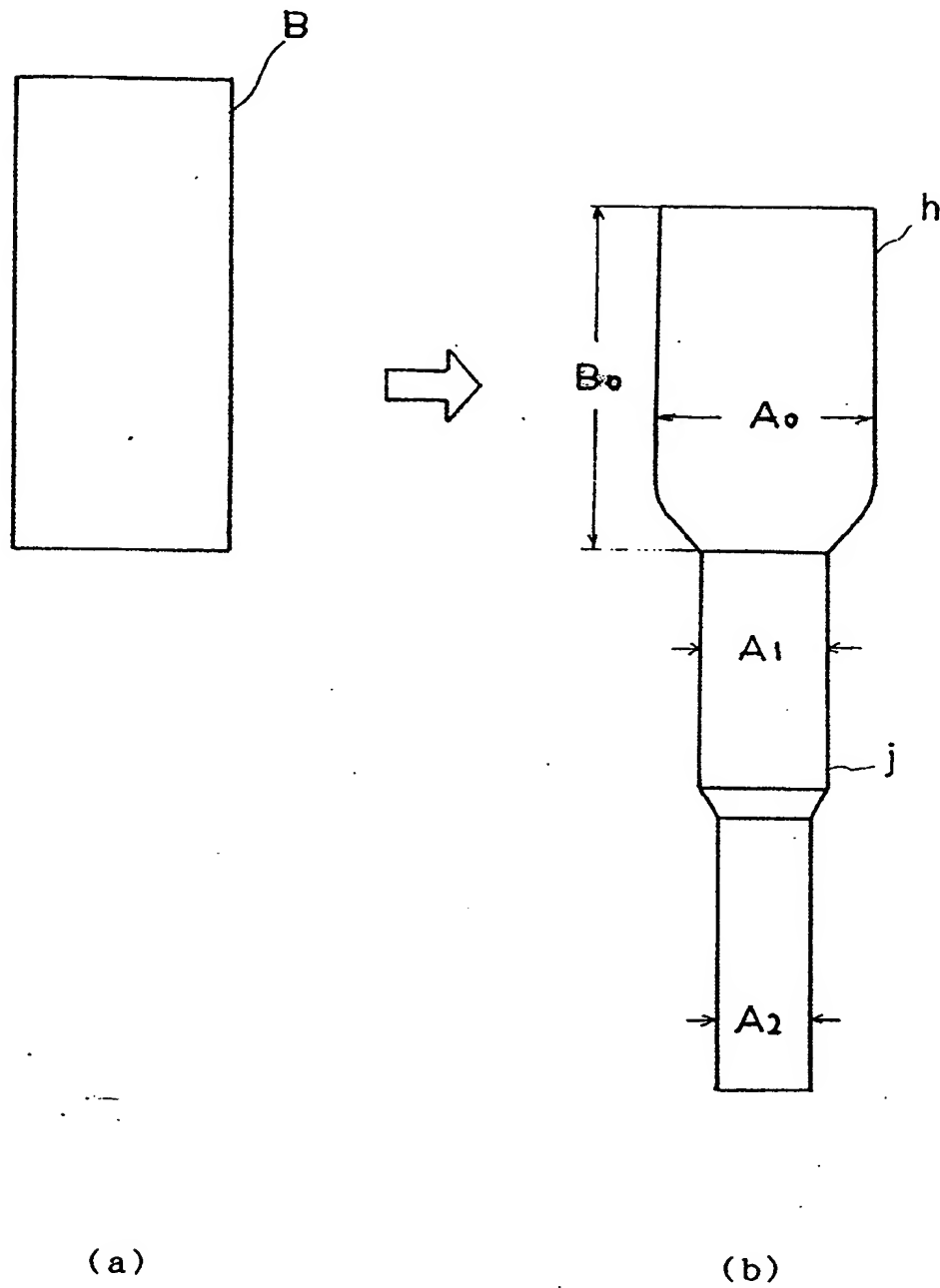
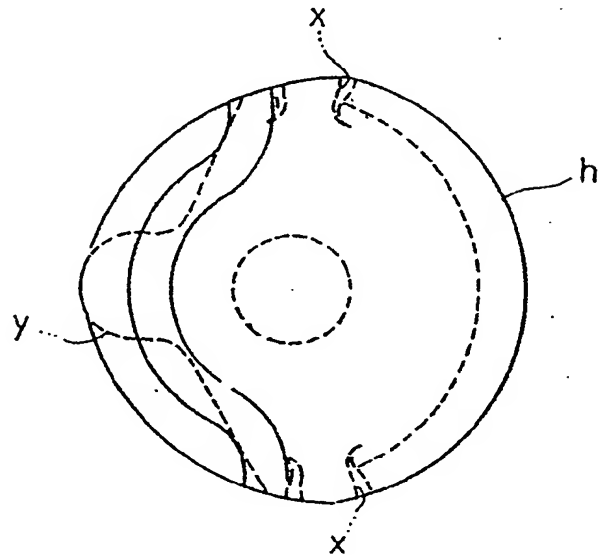
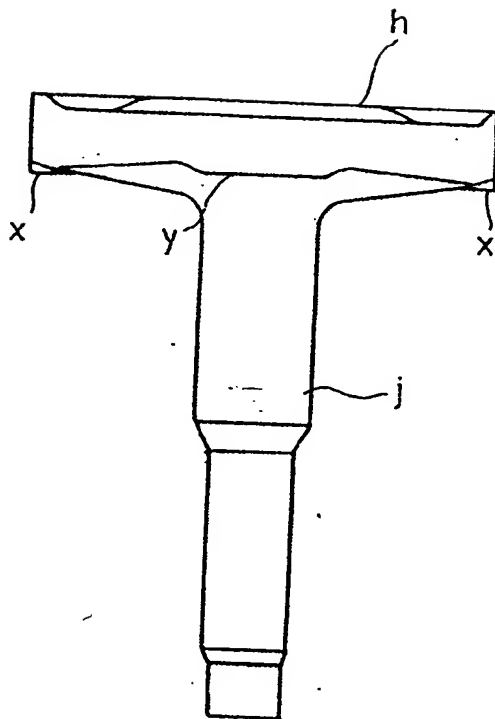




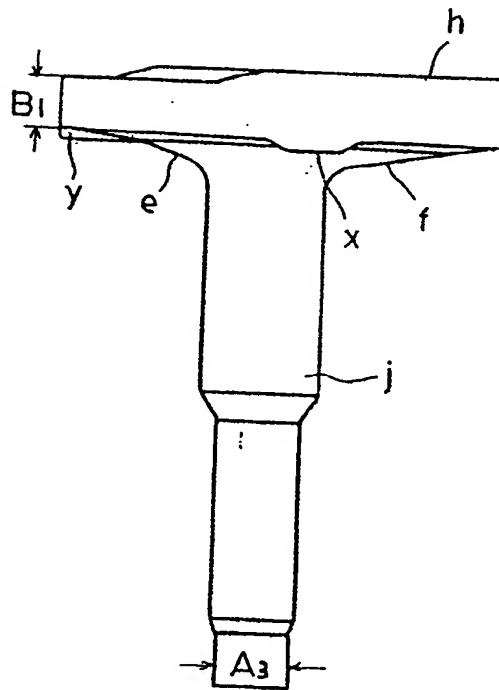
FIG. 30



(a)

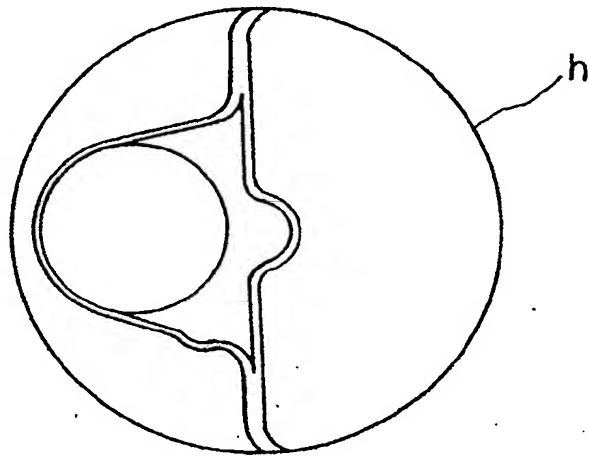


(b)

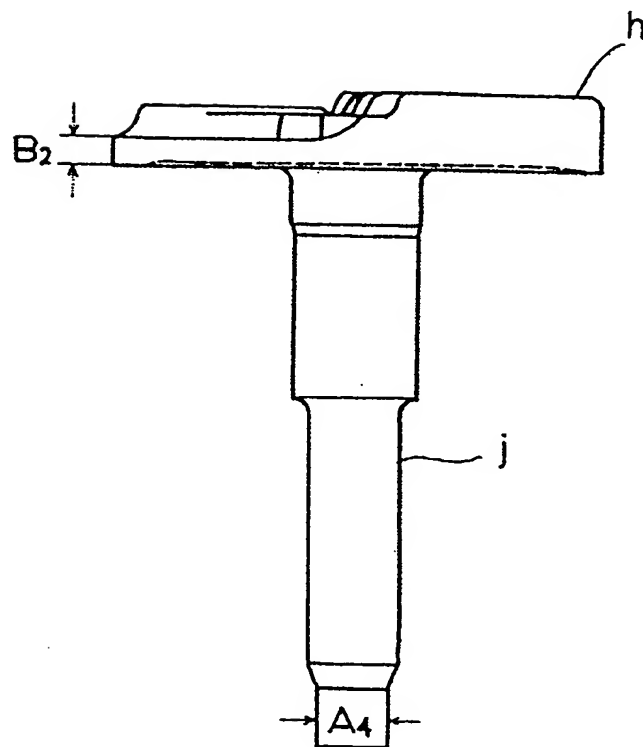


(c)

FIG. 31

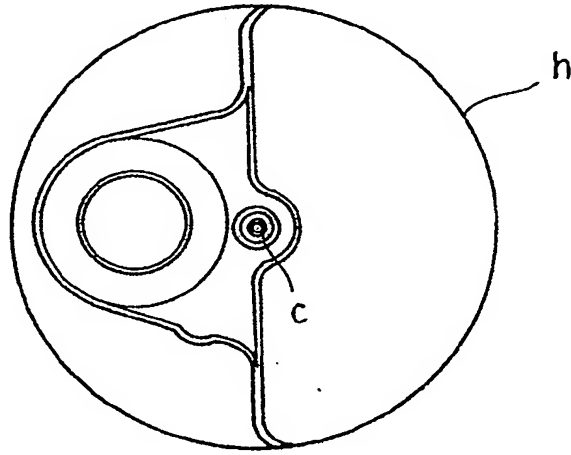


(a)

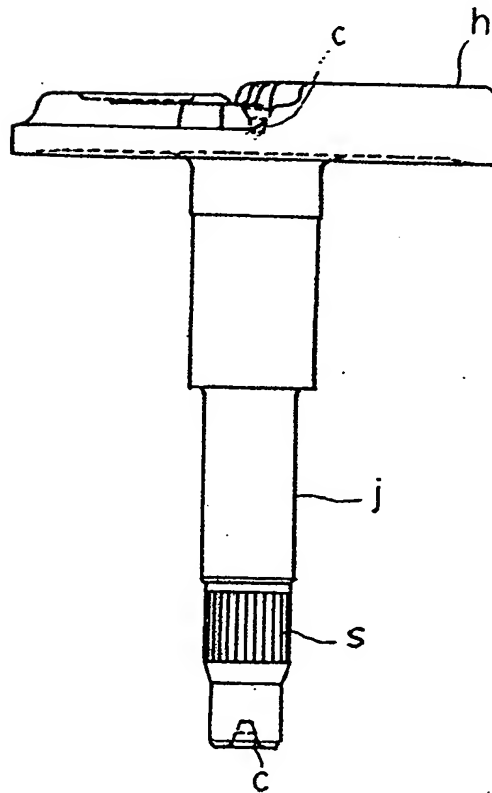


(b)

FIG. 32

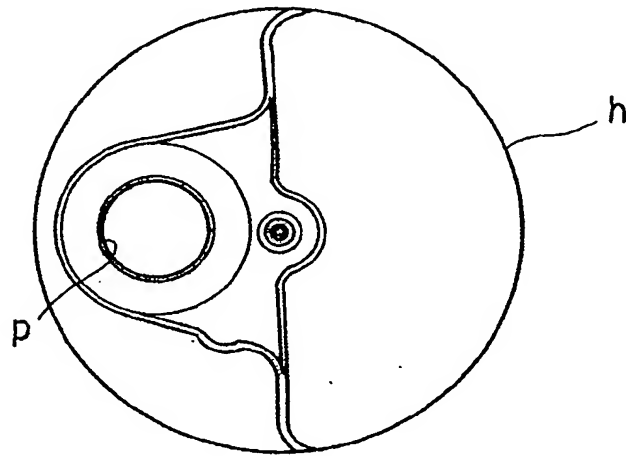


(a)

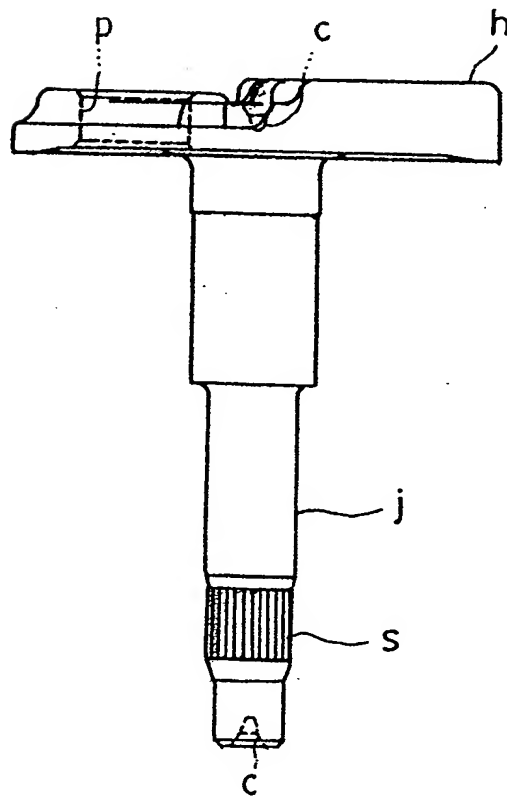


(b)

FIG. 33



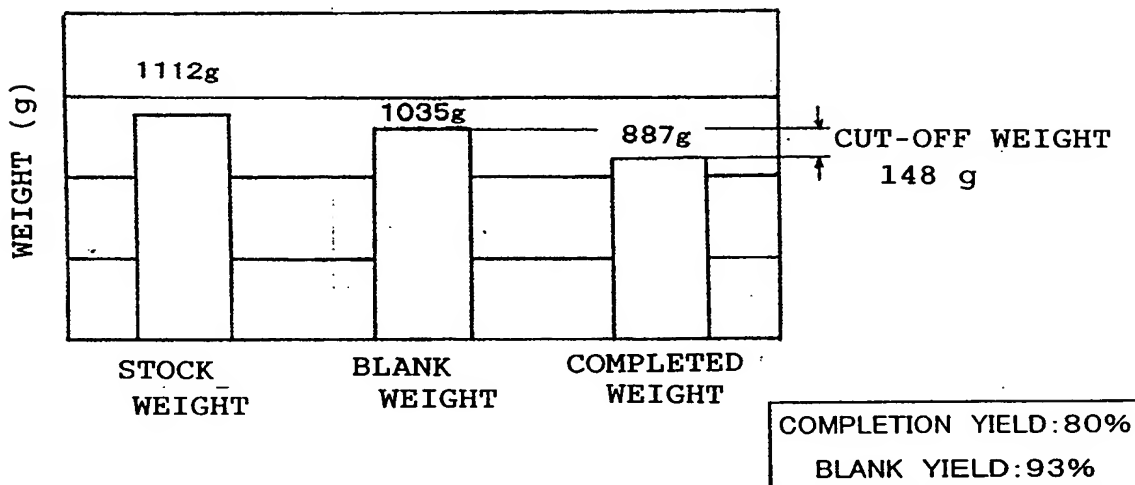
(a)



(b)

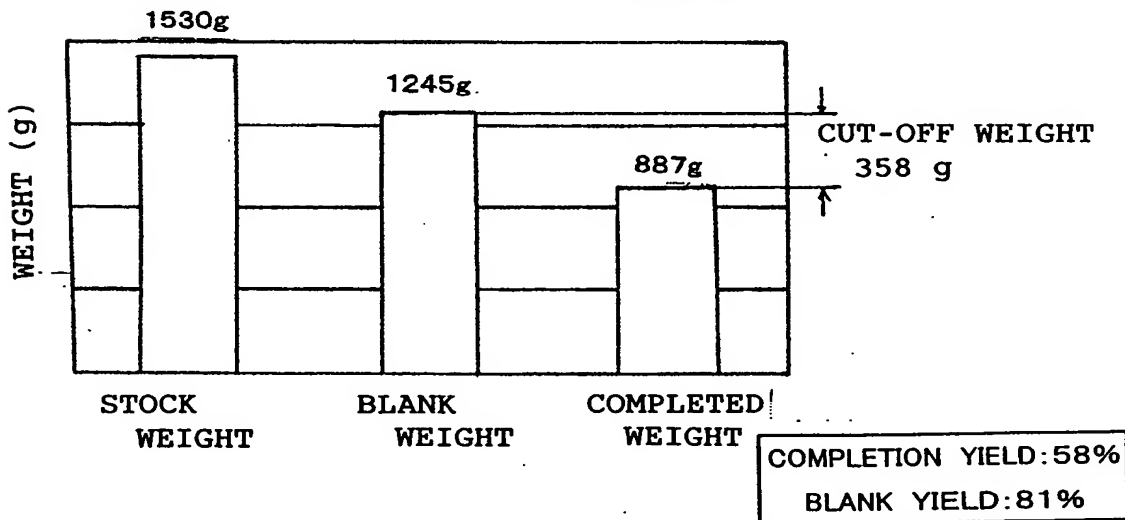
FIG. 34

(INVENTIVE COLD-FORGING METHOD)



(a)

(CONVENTIONAL COLD-FORGING METHOD)



(b)

FIG. 35

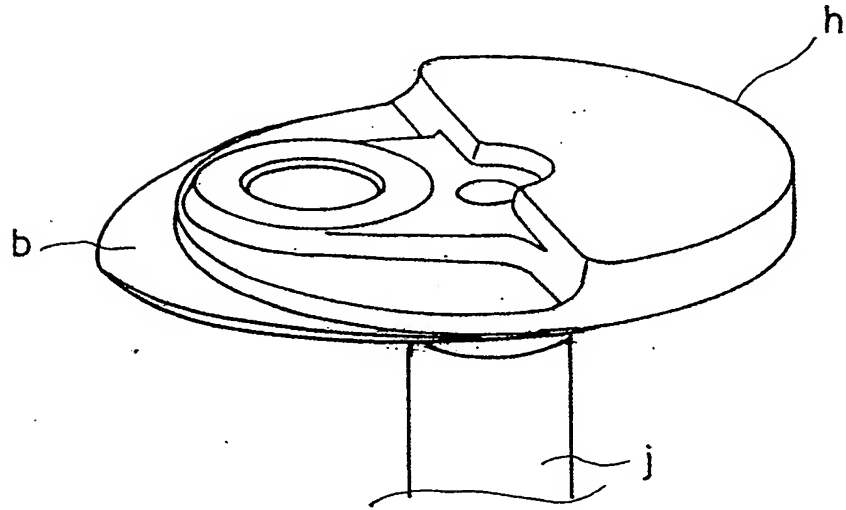
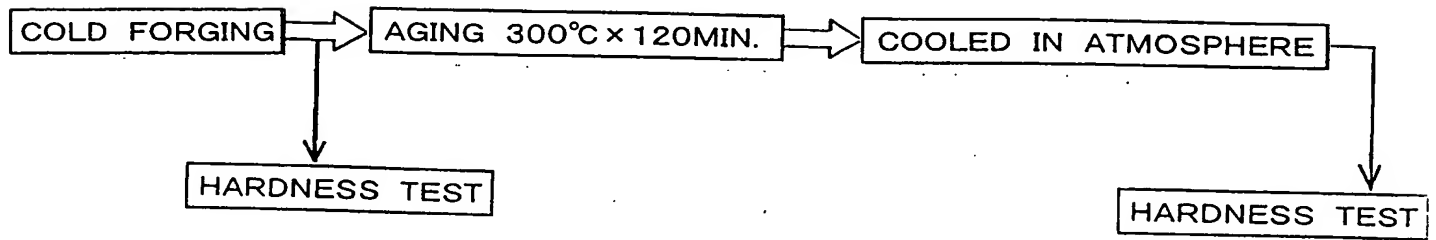
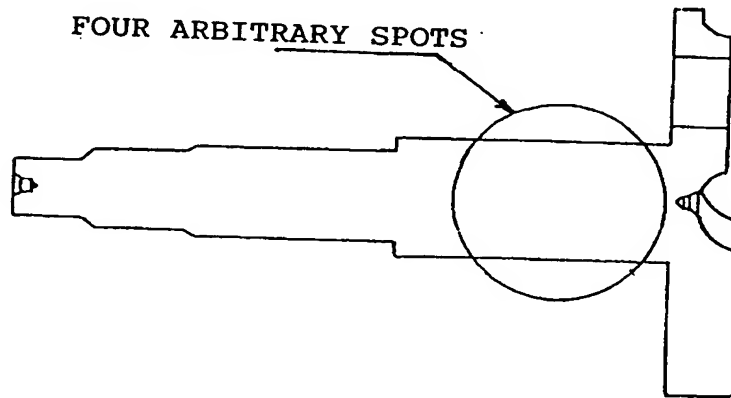


FIG. 36

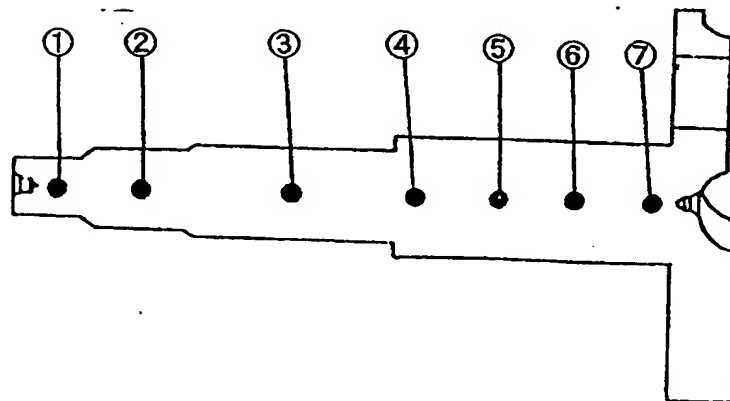


(a)

FOUR ARBITRARY SPOTS



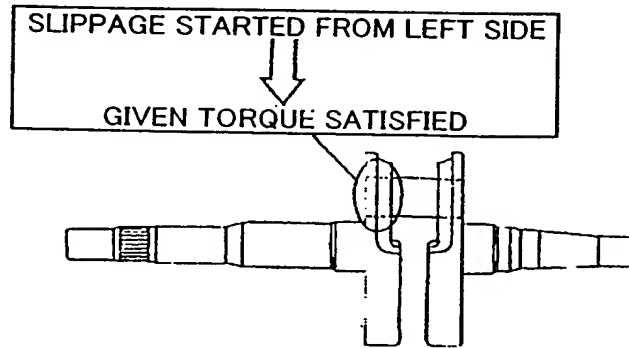
(b)



(c)

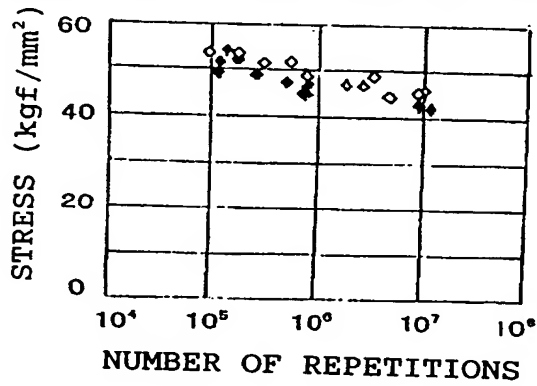
FIG. 37

SLIP TORQUE



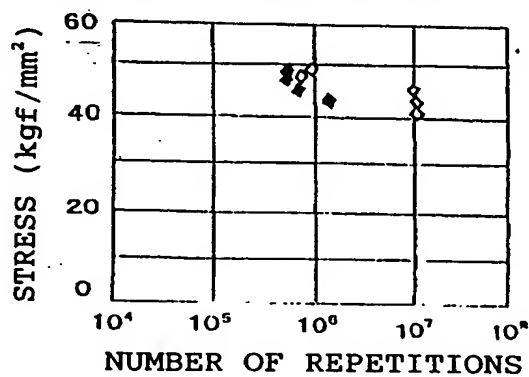
(a)

S - N CURVE (ROTATIONAL BENDING FATIGUE TEST)



(b)

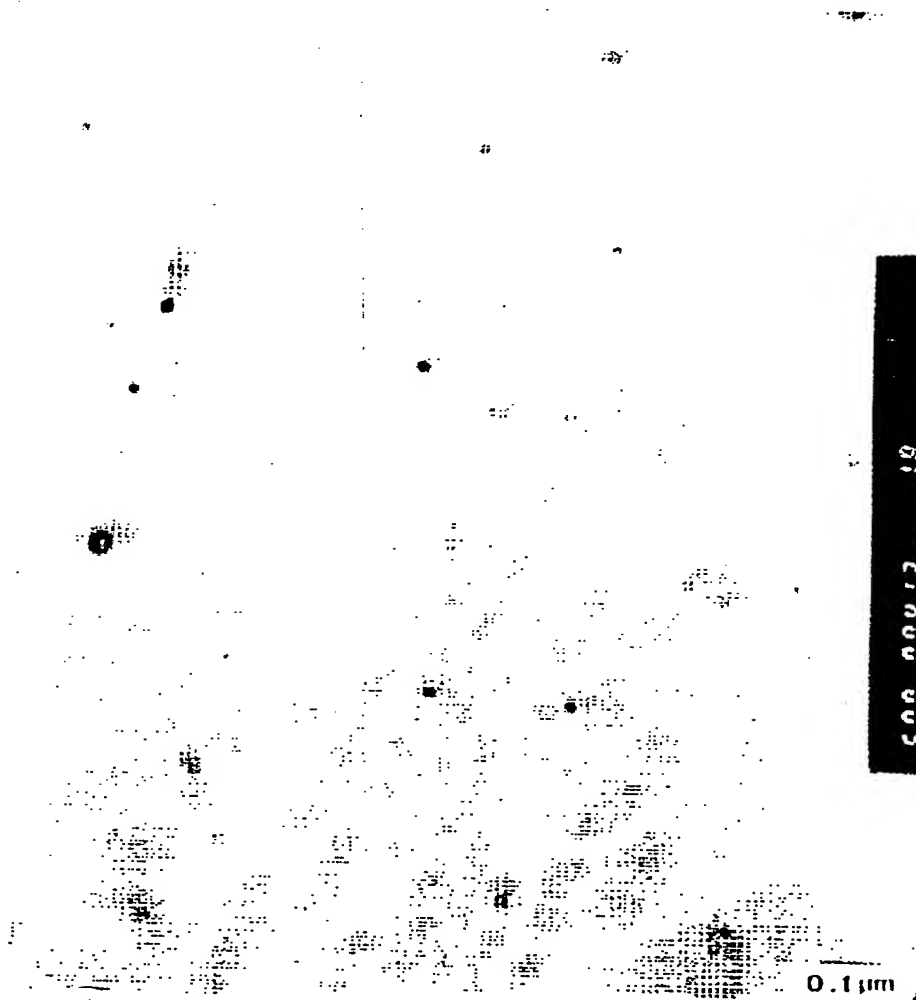
S - N CURVE (SOLID BENDING FATIGUE TEST)



(c)

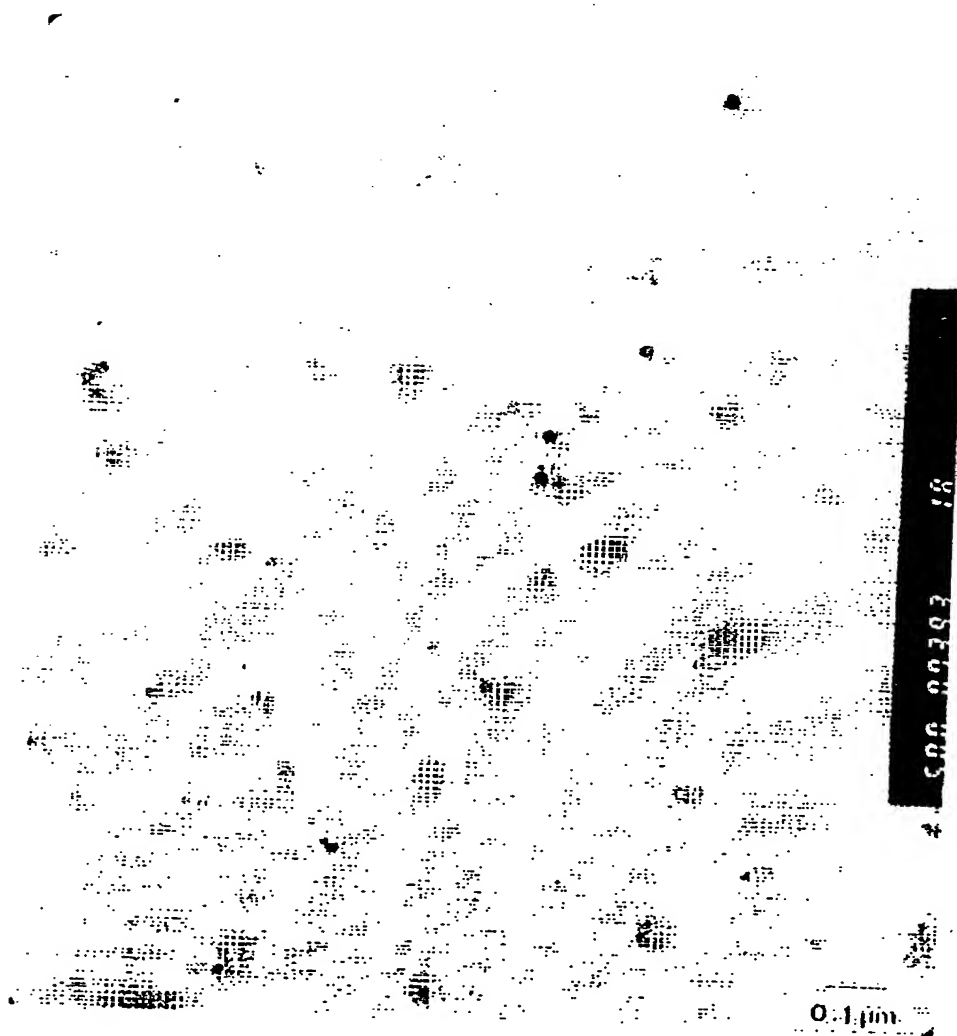


FIG. 38



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FIG. 39

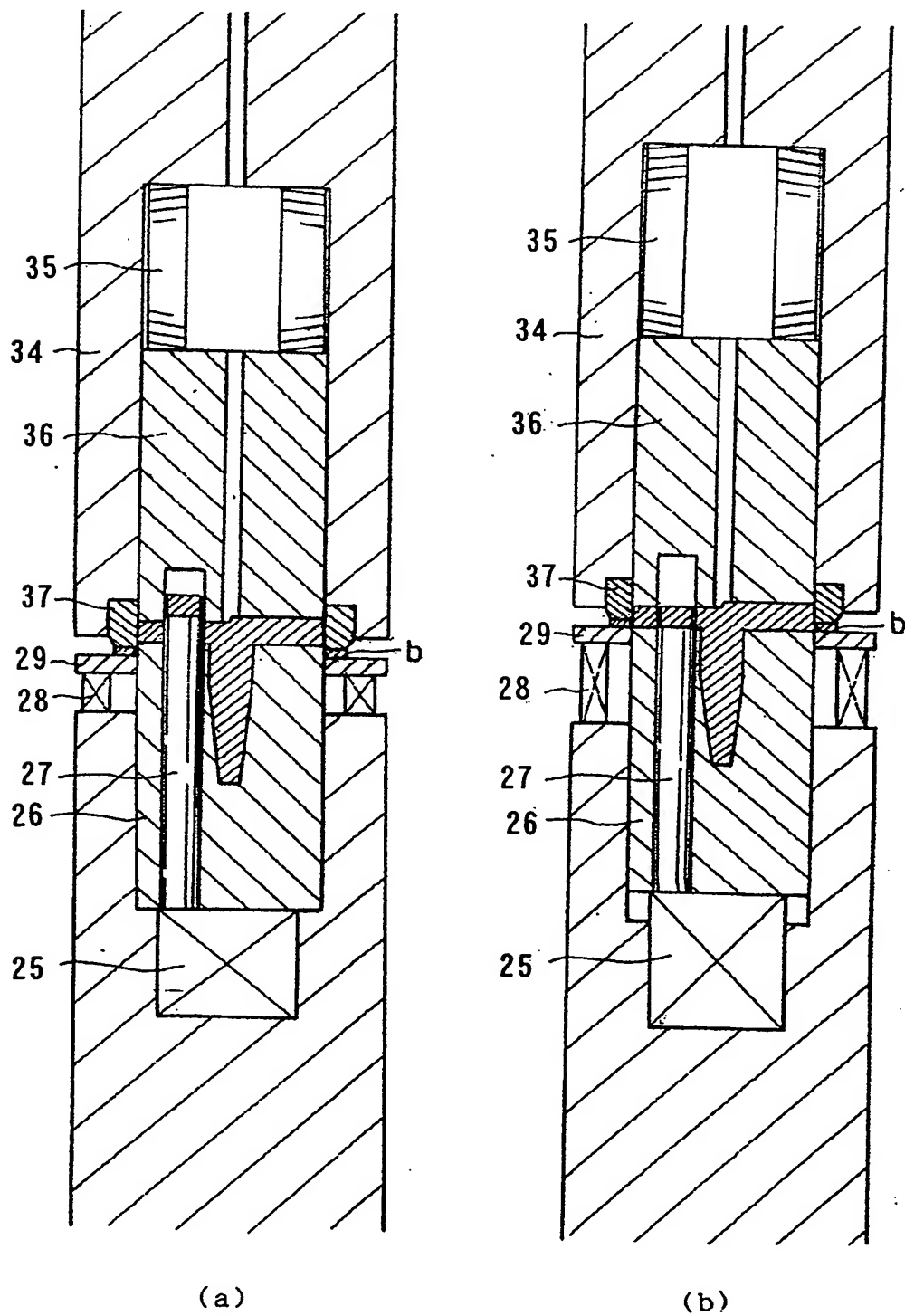


BEST AVAILABLE COPY



FIG. 41

FIG. 42



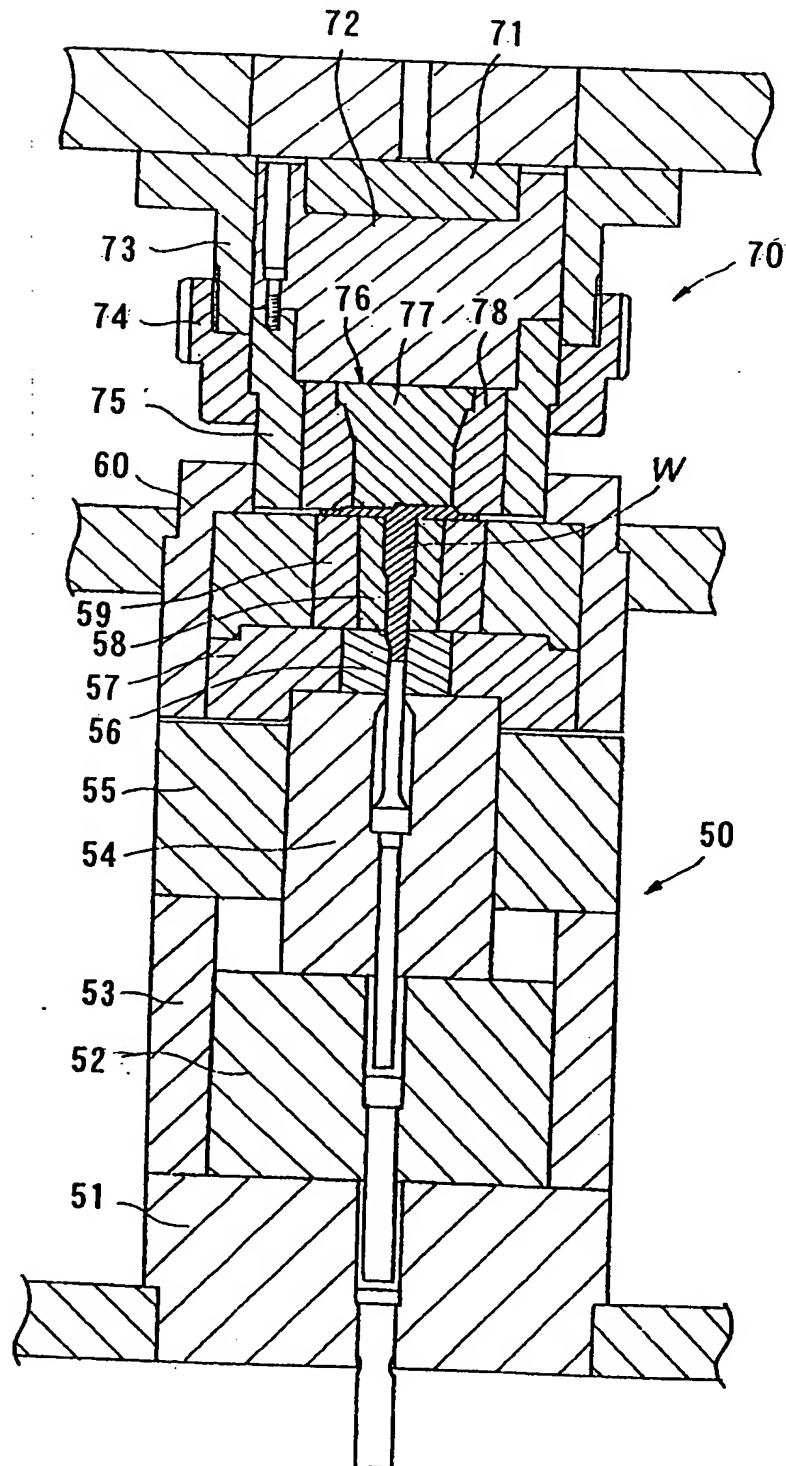


FIG. 44

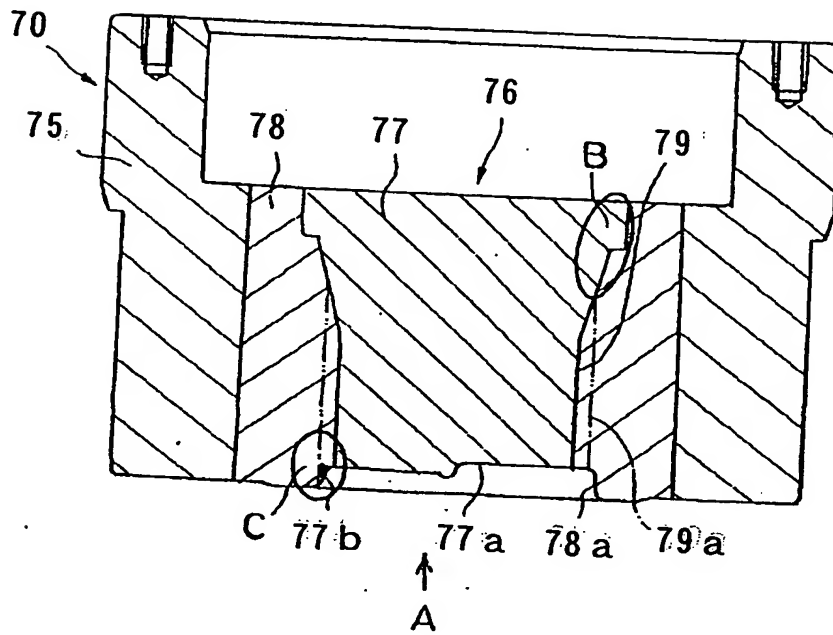


FIG. 45

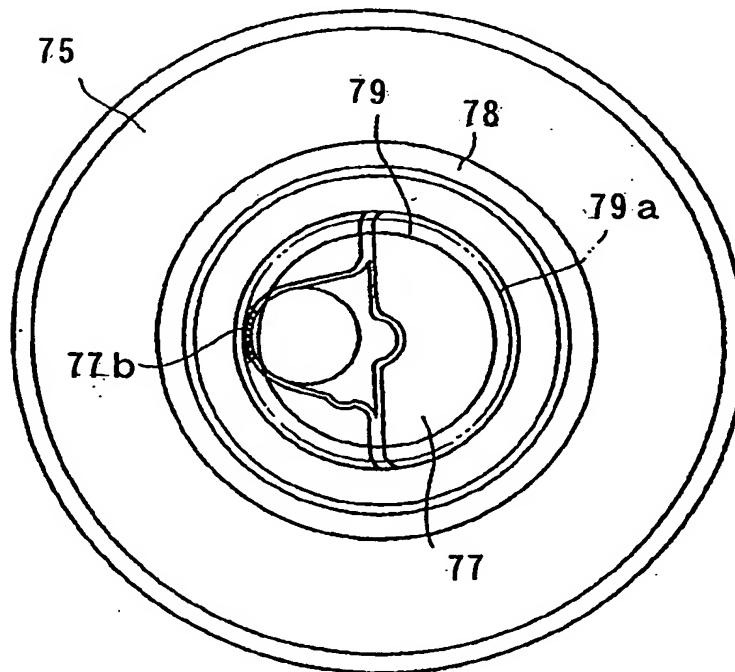


FIG. 46

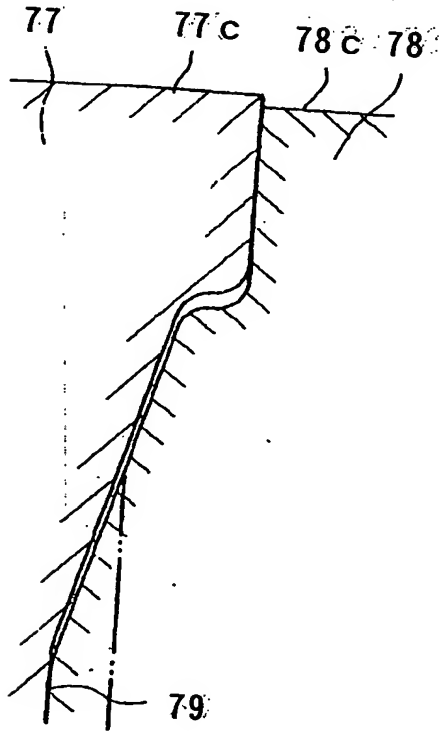


FIG. 47

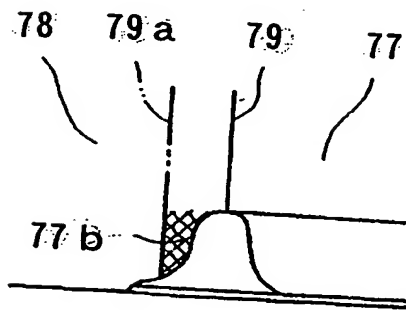






FIG. 49

	Billet manufacturing process					Aspect ratio of carbide (%)	Crack percentage % N=100
	Spherodizing annealing prior to drawing	Drawing	Cutting	Spherodizing annealing subsequent to drawing	Shot bonderizing		
Material 1	None	None	○	○	○	506	35%
Material 2	None	(20%) ○	○	○	○	347	5%
Material 3	○	(20%) ○	○	○	○	300	0%

$$\text{Aspect ratio (\%)} = b/a \times 100$$

